

## SCIENTOMETRIC ANALYSIS OF PHYSICAL CHEMISTRY RESEARCH IN UNIVERSITIES ACCREDITED WITH UPE STATUS IN INDIA

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### ABSTRACT

The present study analyzes the research output in the field of Physical Chemistry by the faculties of 6 Universities selected under UPE (Universities with Potential for excellence) status in the 11<sup>th</sup> plan of UGC (University Grant Commission) in India. The data used for the study was retrieved from ISI Web of Science database- Science Citation Index Expanded (SCIE) for the period 2001-2012. The output of Physical Chemistry literature has been analyzed by year, document type, authorship pattern and collaboration pattern at different levels viz. international, national and local. Results of the study reveal that: i) the physical chemistry literature has grown steadily during the study period except for 2001 and 2003; ii) articles play a predominant source of publication of physical chemistry literature; iii) the physical chemistry research in UPE selected universities of India is fairly collaborative.

**KEYWORDS:** Scientometrics, UPE Status, Citation Impact, Collaboration, Authorship Pattern

### INTRODUCTION

Scientometric is concerned with the quantitative aspect and characteristics of science and scientific research (Scientometric Website, Springer). It is a scientific field that studies the development of science through some quantitative procedures of scientific information, as the number of scientific articles produced in a particular span of time, their citation impact, etc. The background of science and technology, sociology of scientific knowledge and philosophy of science are the associated areas of Scientometric (Harnard, 2009). Scientific productivity is influenced by a huge number of aspects, containing personal attributes such as like sex, age, educational base, psychological aspects etc., further constitutional features like endowment, institutional perspective, and the organization of the actual research (Halil and Darrell, 1998). Chemistry is the central science. It deals with the composition, structure and behavior of the atoms and molecules that make up all forms of matter. Understanding the world at an atomic level is essential to all areas of science. Chemistry is one of the dynamic disciplines being taught in a large number of Universities in India. Chemistry is further divided into sub branches like Organic, Inorganic, Polymer and Physical chemistry. Physical chemistry deals with the application of laws and concepts of physics to chemical system. Its concepts are used to explain and interpret observations on the physical and chemical properties of matter. Physical chemistry is essential for developing and interpreting the techniques used to determine structure and properties, particularly spectroscopy and computational procedures, and their application to the development and understanding of modern materials and biologically important substances (Course Hero, 2013). The Scientometric analysis presented here would be useful to make out significant information and characteristics of Physical Chemistry publications produced as an outcome of research by the faculties.

Presently there are 15 Universities under the scheme of University with potential for Excellence (UPE) in India (UGC, 2013). Of these, 6 Universities are accredited with UPE status during the XI Plan Period (2011) which has been taken into consideration for the present study in order to assess the research performance of faculties of physical chemistry. The aim of the study is to discover the literature growth and research productivity of Indian authors in Physical Chemistry. The scattering of Physical chemistry publications has been surveyed by year, document form, and authorship and collaboration pattern at international and national levels.

## OBJECTIVES

The main objective of the study is to present the growth of literature on Physical Chemistry among Six UPE status Universities in India during the period of 2001 to 2012.

The specific objectives of the study are to:

- Examine the growth of Physical Chemistry research during 2001-2012 by faculties of UPE status universities
- Examine and analyze the authorship pattern in Physical Chemistry literature
- Study impact of research output of the faculties of Universities
- Determine the degree of collaboration in physical chemistry research
- Analyze most prolific author in the field of Physical Chemistry

## SOURCE DATABASE AND METHODOLOGY

The data for the present study were retrieved from ISI Web of Science database – Science Citation Index Expanded (SCIE) for the period 2001 to 2012. The search syntax (string) used for collecting the data for 6 UPE status Universities (Table 1) by general search was as follows:

**WC= (Chemistry Physical) AND OO= (Banaras Hindu Univ) AND PY= (2001-2012)**

The same syntax has been used for other UPE status universities.

A total of 1100 publications of various types viz. Articles (1024), Proceeding papers (62), Reviews (9), Editorial Materials (5) were retrieved from Web of Science. The collected data were analyzed using MS-Excel spreadsheet and MS-Word.

## Scientometric Indicators

Some of the Indices used for the study to analyze the collected data, based on SCIE are as follows:

### Participative Index (PaI)

To evaluate the performance level of research of an institution, an index called ‘Participative Index (PaI)’ has been calculated. PaI is the ratio of the number of papers generated in a country or institution and the total number of documents collected in this repertoire. This can be expressed as:

$$\text{PaI} = \frac{\text{No. of papers generated in an institution}}{\text{Total number of documents collected in this repertoire}} \times 100$$

## **Collaborative Coefficient**

Collaborative Coefficient (CC) suggested by Ajiferuke (1988) and used by Karki and Garg (1997) has been used to quantify the range and potency of collaboration amid the faculties of Physical Chemistry in UPE status universities of India. It can be expressed mathematically as:

$$CC = 1 - \sum_{j=1}^{f=k} \left( \frac{f_j}{N} \right)^k / N \quad (1)$$

Here,  $f_j$  is the number of J authored papers published in a subject during a definite period of time,  $N$  is the total number of research papers published in a subject during a definite period and  $k$  indicates greatest number of authors per paper in a subject.

## **LIMITATIONS OF THE STUDY**

Though there are 15 Universities in India which are selected under University with Potential for Excellence (UPE) scheme, the present study is confined to only 6 Universities (Table 1) because these Universities are added to the scheme in the 11<sup>th</sup> five year plan of University Grant Commission (UGC) during 2011 i.e. recently. The literature analyzed was published during a period of 12 years from 2001 to 2012. Data collection was limited to ISI Web of Science–SCIE which is more comprehensive and widely used for conducting research.

## **ANALYSIS AND INTERPRETATIONS**

### **Distribution of Universities with UPE Status**

Out of 15 UPE selected Universities in India, only 6 Universities were considered for the study.

**Table 1: List of Universities with UPE Status Accredited by UGC in the 11<sup>th</sup> Five Year Plan (2011)**

S. No	Name of the Universities	Year of Establishment	Abbreviation
1	Banaras Hindu University, Varanasi, Uttar Pradesh	1916	BHU
2	University of Mysore, Mysore, Karnataka	1916	MU
3	Osmania University, Hyderabad, Andhra Pradesh	1918	OU
4	KarnatakUniversity, Dharwad, Karnataka	1949	KU
5	University of Rajasthan, Jaipur, Rajasthan	1956	RU
6	Guru Nanak DevUniversity, Amritsar, Punjab	1969	GNDU

Out of the six universities considered for the study Banaras Hindu University, Varanasi (which is the only central university among the other universities), and University of Mysore, Mysore are the oldest universities among the universities which are established in 1916, followed by Osmania University, Hyderabad established during 1918. Guru Nanak Dev University, Amritsar is the youngest university among the other universities which was established during 1969. Among the six universities two universities are from Karnataka State, others from Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab.

### **Growth of Literature**

Journals being the primary source of information they transmit nascent opinions and thoughts which are considered as the forerunner of many inventions and discoveries, especially in science disciplines. Table 2 shows year wise

research output of UPE status universities in India in Physical Chemistry from 2001 to 2012, 1100 scholarly papers were published within twelve years. It is observed that the output of six universities has grown steadily during the period of study from 43 in 2001 to 158 in 2012. However, there was a sudden increase in the output during years from 2009 to 2012 producing 121 (11%), 123(11.18%), 150(13.64%) and 158(14.3%) publications respectively. This shows the considerable evidence that the Universities are giving serious introspection to expand the research infrastructure and enhance its intellectual capital these days.

**Table 2: Year Wise Distribution of Physical Chemistry Literature during 2001-2012**

Year	No. of Articles	Percentage	*Cum. Percent
2001	43	3.91	3.91
2002	51	4.64	8.55
2003	44	4.00	12.55
2004	61	5.55	18.09
2005	72	6.55	24.64
2006	87	7.91	32.55
2007	93	8.45	41.00
2008	97	8.82	49.82
2009	121	11.00	60.82
2010	123	11.18	72.00
2011	150	13.64	85.64
2012	158	14.36	100
<b>Total</b>	<b>1100</b>	<b>100.00</b>	

\*Cum. = Cumulative Percentage

### Forms of Publication

Table 3 presents data on the form wise distribution of Physical Chemistry publications. The majority of the literature output is from journals accounting for 93.09%articles of the total 1100 publications. The publications from Proceeding Papers were 5.63%, followed by Reviews with 0.81%, and editorial materials 0.45%. It is observed that the articles being a prominent source showed a constant increase during the period of study from 2001 to 2012.

**Table 3: Source Wise Distribution of Physical Chemistry Literature during 2001-2012**

Years	Articles	Proceeding Papers	Reviews	Editorial Materials	Total	Percentage of Total
2001	40	3	0	0	43	3.91
2002	43	7	1	0	51	4.64
2003	44	0	0	0	44	4.00
2004	57	2	1	1	61	5.55
2005	69	2	1	0	72	6.55
2006	82	5	0	0	87	7.91
2007	90	2	1	0	93	8.45
2008	87	9	0	1	97	8.82
2009	115	5	1	0	121	11.00
2010	119	2	1	1	123	11.18
2011	142	5	2	1	150	13.64
2012	136	20	1	1	158	14.36
<b>Total</b>	<b>1024 (93.09%)</b>	<b>62 (5.63%)</b>	<b>9 (0.81%)</b>	<b>5 (0.45%)</b>	<b>1100</b>	<b>100.00</b>

### University Wise Performance

Table 4 summarizes year-wise performance of UPE Selected Universities in relation to their contribution in

Physical Chemistry research during the period 2001 to 2012. BHU contributed 38.55 % of PaI and placed first. The encouraging performance is noted in the years 2009 to 2012, which amounted to more than 55% of output, and resulted in 62.25% of year wise variation in Physical Chemistry research output.

The PaI of GNDU is 22.10 % of the total research output of selected Universities during the period of study. The level of variation in research output is 26.56 per cent which is the least amongst all the Universities. The lowest coefficient of variance, in case of GNDU, speaks of the consistent performance of its Faculties throughout the period of study. The RU ranks third in order contributing 13.55% of PaI and Year-wise analysis indicates 85.26 per cent of variation in the output performance.

The Faculty in the KU contributed 11.90 % of PaI to the literature of the total Physical Chemistry research output and is placed fourth. The year-wise variation is 64.11 per cent in the level of research output by this University during the period of study. This variation is mainly due to less output in the years 2001 to 2005 and in 2008. The OU occupied the fifth position with 9.18% of PaI in total literature output and its year wise variation is 54.20 per cent.

The contribution of the remaining University that is the MU is 4.72% of Pa I, it occupied last position among all other Universities. Its year wise variation in the performance output is 35.93. Even though its year wise variation is low, but its contribution to the total research output i. e Participative Index is poor.

From the above analysis, it can be deduced that BHU shares 38.55per cent of Pa I in total Physical Chemistry research output over the period of study. The other ranked Universities are GNDU 22.10 %, RU 13.55 %, and KU 11.90 %, respectively. The OU and the MU share the last position of research productivity. The highest level of variation is 85.26 percent found in the RU.

**Table 4: University Wise Distribution of Research Output of Physical Chemistry Literature during 2001-2012**

Universities	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total	PaI*	SD*	Mean	CV
BHU	18	22	15	18	23	21	27	31	43	55	78	73	424	38.55	21.99	35.33	62.25
GNDU	12	12	17	23	26	25	18	24	17	17	25	27	243	22.10	5.37	20.25	26.56
KU	3	6	4	5	4	21	20	9	22	12	14	11	131	11.90	6.99	10.91	64.11
OU	3	1	4	8	12	7	8	7	17	13	12	9	101	9.18	4.56	8.41	54.20
MU	4	7	1	4	5	5	6	4	5	3	5	3	52	4.72	1.556	4.33	35.93
RU	3	3	3	3	2	8	14	22	17	23	16	35	149	13.55	10.58	12.41	85.26
Total	43	51	44	61	72	87	93	97	121	123	150	158	1100	100	39.67	91.66	43.28

\*PaI= Participative Index \*SD= Standard Deviation \*CV= Coefficient of Variance

### Authorship Pattern

It is a well-known fact that nowadays, research is carried out by a group of researchers rather than by a single researcher. The objective of the study of the authorship pattern is to bring out the research pattern in a discipline. Considering the above fact, an effort has been made to identify the nature of the authorship pattern in scientific research output made by the UPE selected Universities of India. This study not only facilitates one to recognize the enormity of research interests among the physical chemistry faculties but also explains their impact in the form of research papers in any year of the study period.

In Table 5, it could be noted that three authored papers rank first in order of sharing 27.7% of the total research output. The year wise consideration shows that the performance of three authored papers has been increasing in almost all the years. The five and more than five authored papers follow second in order with 24.5% of the total research contributions followed by four authored papers contributing 23.3% of the total scientific research output during the study

period respectively. While the contribution of the two authored papers is 22.5% of the total research productivity. It is an interesting to identify that one-authored papers stand in the sixth position observing 22 contributions, which represents only 2 %.

Based on the data reflected in Table 5, the Collaborative Co-efficient (CC) using equation 1 was calculated. The calculated value of Collaborative Co-efficient (see last row of Table 6) for the study period does not vary much for different years. The value of CC is lowest 0.58 for 2001 and highest 0.69 for two years 2007and2008. This indicates that the physical chemistry research among faculties of UPE selected Universities in India is fairly collaborative.

**Table 5: Year Wise Distribution of Authorship Pattern**

Authorship Pattern	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total	Average	Mean	SD	CV
1	6	0	1	1	0	2	2	2	2	5	0	1	22	2	1.8	1.90	103.5
2	10.0	11.0	13.0	17.0	25.0	18.0	16.0	16.0	22.0	20.0	37.0	43.0	248.0	22.5	20.7	10.08	48.7
3	16.0	14.0	20.0	17.0	22.0	18.0	25.0	23.0	44.0	38.0	37.0	31.0	305.0	27.7	25.4	9.82	38.6
4	6.0	18.0	12.0	14.0	12.0	22.0	25.0	30.0	24.0	27.0	32.0	34.0	256.0	23.3	21.3	8.93	41.8
>5	7.0	6.0	5.0	14.0	17.0	18.0	30.0	23.0	31.0	35.0	44.0	39.0	269.0	24.5	22.4	13.35	59.5
<b>Total</b>	<b>45</b>	<b>49</b>	<b>51</b>	<b>63</b>	<b>76</b>	<b>78</b>	<b>98</b>	<b>94</b>	<b>123</b>	<b>125</b>	<b>150</b>	<b>148</b>	<b>1100</b>	<b>100</b>	<b>91.7</b>	<b>37.68</b>	<b>41.1</b>
*CC	0.58	0.68	0.65	0.67	0.66	0.67	0.69	0.69	0.68	0.67	0.68	0.67	0.67				

\*CC= Collaborative Co-efficient

### Collaboration Trends

It was found that the international collaboration is highest i.e. 36.9% followed by national 35.6% and local collaborations i.e. 27.4%. In the twelve-year period, 2011 was found to be the most productive, where the percentage of international collaboration was 15.76%, national collaboration was 13.01% and local collaboration was 14.57%. Collaboration at national and local levels was also good during the study period. Collaboration at international, national and local level was lowest in 2001.

Through collaboration, the researchers share and exchange knowledge and techniques, those bring in a mixture of positive scientific thoughts and decrease cost at the same time. Scientometricians have paid due attention to these phenomena ever since. Intensifying co-author relationship has been reported for all fields and at practically all levels of agglomeration, for example, by Glanzel (Glanzel W, 2001) for the macro level, by Gomez (Gomez I, 1995) for the meso level, and Ding (Ding et al, 1999) and Glanzel (Glanzel, 2002) for the micro level. As a result, multi-authorship necessarily increases the productivity and always results in high citation impact. Contemplating the above fact, the present study analyzed the nature of collaboration among the faculties of Physical Chemistry in UPE selected Universities of India as seen in Tables 6 &7.

With regard to performance of collaboration amongst 6 Universities, the BHU holds 39.40%, 36.15% and 14.29% followed by GNDU, which gains 24.94%, 12.31% and 15.58% for International, National and Local respectively. It is interesting, to note the international collaboration among the faculties at the BHU 39.40% and the GNDU (24.94%) accounts for 64.34% of the total. The RU stands in third position with 12.22%, 19.74% and 21.10% for International, National and local respectively. The OU collaboration is good at national 13.85% and local level 16.23% compared to International 7.73%.

The MU shows the average collaboration and the local collaboration stands high with 15.91%. Whereas the KU

faculties' performance is poor compared to all five other Universities, it is least in both the International 6.23% and National 8.72% collaboration and its local collaboration is 16.88%.

As a result, it could be noticed that collaboration at International and National levels among the faculties of Physical Chemistry in UPE selected Universities of India is fairly good. The reason could be that the ICT has condensed geographical hurdles opening up potentials for collaboration.

**Table 6: Year Wise Analysis of Collaboration Trends among the Faculties**

Year	IC	%	NC	%	LC	%	Total	%
2001	20	4.93	16	4.08	11	3.64	47	4.27
2002	23	5.67	23	5.87	13	4.30	59	5.36
2003	26	6.40	21	5.36	14	4.64	61	5.55
2004	23	5.67	20	5.10	15	4.97	58	5.27
2005	29	7.14	20	5.10	18	5.96	67	6.09
2006	26	6.40	24	6.12	25	8.28	75	6.82
2007	36	8.87	34	8.67	34	11.26	104	9.45
2008	34	8.37	46	11.73	26	8.61	106	9.64
2009	36	8.87	52	13.27	29	9.60	117	10.64
2010	46	11.33	42	10.71	39	12.91	127	11.55
2011	64	15.76	51	13.01	44	14.57	159	14.45
2012	43	10.59	43	10.97	34	11.26	120	10.91
<b>Total</b>	<b>406 (36.9%)</b>	<b>100.00</b>	<b>392 (35.6%)</b>	<b>100.00</b>	<b>302 (27.4%)</b>	<b>100</b>	<b>1100</b>	<b>100.00</b>

\*IC= International Collaboration

\*NC=National Collaboration \*LC= Local Collaboration

**Table 7: University Wise Analysis of Collaboration Trends**

Universities	IC	%OF IC	NC	%OF NC	LC	%OF LC	Total	Total%
<b>BHU</b>	158	39.40	141	36.15	44	14.29	343	31.18
<b>GNDU</b>	100	24.94	48	12.31	48	15.58	196	17.82
<b>KU</b>	25	6.23	34	8.72	52	16.88	111	10.09
<b>OU</b>	31	7.73	54	13.85	50	16.23	136	12.36
<b>MU</b>	38	9.48	36	9.23	49	15.91	123	11.18
<b>RU</b>	49	12.22	77	19.74	65	21.10	191	17.36
<b>Total</b>	<b>401</b>	<b>100</b>	<b>390</b>	<b>100</b>	<b>308</b>	<b>100</b>	<b>1100</b>	<b>100</b>

### Prolific Authors

Table 8 depicts the picture of the prolific authors who have produced more than ten articles in Physical Chemistry during the period of study. The findings of distribution of authors in terms of their number of contributions reveal that Bakshi, M. S. from Guru Nanak Dev University is in the First place with 80 publications in Physical Chemistry. Nandibewoor, S. T. from Karnatak University, Dharwad with 59 publications secured second place, followed by Srivastava, O. N. from Banaras Hindu University, with 55 articles secured third place.

**Table 8: Prolific Authors Producing More Than Ten Articles**

Name	No. of Contributions	Affiliation Address
Bakshi, M.S.	80	Guru Nanak Dev University, Amritsar, Punjab.
Nandibewoor, S.T.	59	Karnatak University, Dharwad, Karnataka.
Srivastava, O.N.	55	Banaras Hindu University, Varanasi, Uttar Pradesh.
Mishra, P. C	49	Banaras Hindu University, Varanasi, Uttar Pradesh.
Jain, I.P.	41	University of Rajasthan, Jaipur, Rajasthan.

**Table 8: Contd.,**

Vijay, Y. K.	33	University of Rajasthan, Jaipur, Rajasthan.
Banipal, T.S.	32	Guru Nanak Dev University, Amritsar, Punjab.
Kaur, G.	32	Guru Nanak Dev University, Amritsar, Punjab.
Kaur, D.	31	Guru Nanak Dev University, Amritsar, Punjab.
Singh, R. K.	30	Banaras Hindu University, Varanasi, Uttar Pradesh.
Singh, AK..	29	Banaras Hindu University, Varanasi, Uttar Pradesh.
Mahajan, R.K.	29	Guru Nanak Dev University, Amritsar, Punjab.
Singh, K.	25	Guru Nanak Dev University, Amritsar, Punjab.
Jain, A.	24	University of Rajasthan, Jaipur, Rajasthan.
Singh, R.N.	22	Banaras Hindu University, Varanasi, Uttar Pradesh.
Asthana, B.P.	18	Banaras Hindu University, Varanasi, Uttar Pradesh.
Singh, N.K.	17	Banaras Hindu University, Varanasi, Uttar Pradesh.
Kumar, A.	16	Banaras Hindu University, Varanasi, Uttar Pradesh.
Shukla, P. K.	16	Banaras Hindu University, Varanasi, Uttar Pradesh.
Banipal, P.K.	16	Guru Nanak Dev University, Amritsar, Punjab.
Sekhon, S. S	16	Guru Nanak Dev University, Amritsar, Punjab.
Singh, S.	16	Guru Nanak Dev University, Amritsar, Punjab.
Parkash, O.	15	Banaras Hindu University, Varanasi, Uttar Pradesh.
Rai, S. B.	15	Banaras Hindu University, Varanasi, Uttar Pradesh.
Chimatadar ,S.A.	15	Karnatak University, Dharwad, Karnataka.
Singh, S.	15	Banaras Hindu University, Varanasi, Uttar Pradesh.
Aminabhavi, T.M.	14	Karnatak University, Dharwad, Karnataka.
Srivastava, S. K.	14	Banaras Hindu University, Varanasi, Uttar Pradesh.
Singh, M.	14	University of Rajasthan, Jaipur, Rajasthan.
Agarwal, S.	13	University of Rajasthan, Jaipur, Rajasthan.
Rai, R.N.	12	Banaras Hindu University, Varanasi, Uttar Pradesh.
Kumar, S.	12	University of Rajasthan,Jaipur, Rajasthan.
Maiti, P.	11	Banaras Hindu University, Varanasi, Uttar Pradesh.
Ojha, A.K.	11	Banaras Hindu University, Varanasi, Uttar Pradesh.
Singh, S. K.	11	Banaras Hindu University, Varanasi, Uttar Pradesh.
Srivastava, A.	11	Banaras Hindu University, Varanasi, Uttar Pradesh.
Bharatam, P. V.	11	Guru Nanak DevUniversity, Amritsar, Punjab.
Chimni, S. S.	11	Guru Nanak DevUniversity, Amritsar, Punjab.
Sachar, S.	11	Guru Nanak DevUniversity, Amritsar, Punjab.
Singh, J.	11	Guru Nanak DevUniversity, Amritsar, Punjab.
Sood, R.	11	Guru Nanak Dev University, Amritsar, Punjab.
Bharatam, P. V.	11	Guru Nanak Dev University, Amritsar, Punjab.
Jain, R.K.	11	University of Rajasthan, , Jaipur, Rajasthan.
Kumar, S.	10	Banaras Hindu University, Varanasi, Uttar Pradesh.
Prakash, R.	10	Banaras Hindu University, Varanasi, Uttar Pradesh.
Singh, P.	10	Banaras Hindu University, Varanasi, Uttar Pradesh.

## CONCLUSIONS

The analysis of literature in physical chemistry contributed by the faculties in UPE selected universities in India brings forward few noteworthy facts about the literature together with the authors. The pattern of year-wise output is in an upward position from year to year. Research output of the BHU faculty stands top followed by the GNDU, RU, KU, OU and MU. PaI of 38.55% for BHU reflects its contribution in the literature shared by its faculty. Collaborative of authors in research is marked by the verity that 22.39%, 27.91%, 23.15% and 24.42% of research papers have been published by two, three, four and five authors respectively. The nature of collaboration trend among faculties is at international and national levels. It indicates the faculties' upward sight for collaboration. Major individual contribution is from the GNDU, i.e. Bakshi, M S published 80 publications followed by Nandibewoor, S.T. of KU who contributed 59 articles.

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